ENGINEERING

Regional Supervisor, Branch of Refuges

February 3, 1959
ER

Regional Engineer

Lake Andes Refuge, South Dakota -- Water Management Program 1959

Returned herewith is a copy of the subject plan which was furnished to us for review.

We concur in the proposed plan of water regulation.

It is suggested that we be kept informed of any plans of the Soil Conservation Service and Bureau of Reclamation whereby we might obtain an additional water supply for the refuge. We wish to investigate the diversion possibilities at the appropriate time.

John D. Umberger

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WATER MANAGEMENT PROGRAM

LAKE ANDES REFUGE

1959

A. Conditions in 1958

1. Weather

In general the 1958 season was very dry. There was 15 inches of precipitation up to December 1; normal is about 24 inches for the year. There were good rains in April and July but since mid-August there has been practically no rain. The South unit froze over on November 23 and Owens Bay on November 26.

2. Water

All units except Owens Bay started out at relatively low levels in 1958. The North unit was at 93.2, the Center unit at 91.0, and the South unit at 92.2 at the first of the year. They all increased from one to two feet during the spring runoff then began to decline. The North and Center units both went dry on August 30. The South unit has receded so far from the dike it is impossible to gauge it but there couldn't be more than one or two feet of water in it. Very likely the water from Owens Bay has contributed enough to keep the South unit from drying up completely.

Owens Bay spillway was closed during the winter in the hopes there would be a fish kill in the South unit. It reached 5.2 feet before the spillway was opened. According to the previous Water Management Plan Owens Bay was to be held at 3.5 feet this year. The best that could be done with the present set of stoplogs was 3.3 feet; it was held at this level all summer and fall.

The well at Owens Bay continues to put out about 1000 gpm. During the summer this was just barely enough to maintain Owens Bay. There was just a trickle at the spillway in August. At the present time there is a good flow going over the spillway.

At the end of the year the North and Center units are completely dry, the South unit has bewteen one and two feet of water at the most, and Owens Bay is still at the 3.3 level.

3. Habitat

The North unit had a very good stand of Sago pondweed as long as it had water. It was a solid stand in July. There were a few small clumps of hardstem bulrush in the lower third of the unit but they probably did not take up more than 2% of the total area. Most of the shoreline is grazed, and because pasture conditions were very bad this year cattle took most of the new emergent vegetative growth.

The Center unit was very similar to the North unit except that the sago comprised about one third to one half of the total area. It was very easy to see the effect of carp on submerged aquatic vegetation this summer. Apparently the North unit did not have any carp in the last few years and consequently it had a very good stand of sago. The Center unit had carp but they were all killed a year ago and the unit had about half a stand of sago. The South unit has had carp right up until this fall and it doesn't have any submerged aquatic vegetation at all.

Emergent vegetation and dry land vegetationiis coming in on the higher parts of the South and Center units but because the water receded so fast there is a considerable stretch of bare shoreline between the vegetation and water.

Owens Bay was somewhat of a problem in vegetation. In 1957 there was a dense stand of Kochia and sweet clover over much of the dry bottom. This remained standing all this year. Algae was dominant in most of the open water and the remainder was occupied by river bulrush and hard stemm bulrush. The pool could be roughly divided with about a third of the area in each of these types. There was very little vegetative growth among the standing dead weeds but this seemed to make excellent brood cover during the summer. In the open water where algae was dominant it almost completely smothered sago pondweed. There was sago all through the area but it never produced many seeds. In the east half of the pool river bulrush, although not in solid stands, was dominant by far. In general the vegetation was fair to good. It could be rated very good for brood cover because there was so much cover it was almost impossible to count broods.

4. Wildlife

Waterfowl production on the refuge was not as high this year as last. Apparently this was a matter of water distribution because there was some indication that more broods were raised on potholes and stock dams in the area. Waterfowl use on the refuge was up, mainly due to an increase in molting drake pintails and mallards, and flying broods later on.

Waterfowl use was correlated pretty closely with vegetation. The North unit had a very good population of ducks with its good stand of sago. The Center unit had about the same number as the North unit but they were distributed over a larger area. The South unit had practically no production or waterfowl use. Owens Bay had fairly good production but was comparatively low on waterfowl use. A flock of nine Canada geese were seen on the Center unit in July - there is a good possibility that a family group was present all summer.

Waterfowl use this fall was down considerably, partly because of the lack of water and partly because of a decrease in migration. The peak population this fall was 20,000 mallards compared with 328,000 last year.

All fish were eliminated in the North and Center units when they went dry. All that were seen in the North unit was a good number of bullheads. No fish were seen in the Center unit at all. Presumably they were all killed in 1957. There was a good population of carp, with a few bullheads and perch in the South unit. About 1/3 of them died in early August. It was completed in September with a heavy Toxaphene application. There has been no sign of fish life since then.

The State has put bass in Owens Bay on at least three occasions this year as well as 9000 bluegills in November. These will be used for brood stock, for stocking the main lake and elsewhere.

There were about six muskrat houses on Owens Bay and none on the main lake this fall.

B. Recommendations for 1959

1. Water Levels

In the North, Center and South units there is very little that can be done about regulating water levels. If by any chance there should be enough runoff to fill any or all of the units it is recommended that the North and South units be filled first before spilling water into the Center unit. This is as recommended in the Water Management Plan, to hold as much water as possible against evaporation loss.

Owens Bay should be held at the 4.0 foot level in 1959 to continue the study of the effect of flooding new shoreline for waterfowl habitat. Two vegetative transects were set up in Owens Bay in 1958, one across the pool and one along the shoreline. These will be checked again in 1959, as well as periodic counts on waterfowl use during the year.

2. Water Supply

According to the Reconnaissance Survey made by the Soil Conservation Service in 1958 (see Water Management Plan) there is a possibility of adding additional drainage into the lake from the hills south of the South unit, and also from the west through the present diversion ditch. I would like to recommend a thorough survey by the Branch of Engineering to investigate these possibilities. It appears that the channel block in the diversion ditch at Garden Creek could have culverts installed that would pass as much water as the ditch could handle with no danger of flooding nearby farm land.

December 18, 1958

Submitted by:

David C. McGlauchlin

David C. McGlauchlin
Refuge Manager

Approved:

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WATER MANAGEMENT PLAN

LAKE ANDES REFUGE

I. Refuge Water Management

(A) History

Lake Andes is a natural prairie lake of about 4500 acres. Except for artesian wells, the lake is fed by runoff from a watershed of abput 84,800 acres. There are no permanent streams emptying into the lake. There was no outlet from the lake until a concrete tube was installed in 1934. The water supply, other than that from artesian wells, is entirely dependent on precipitation and evaporation.

As would be expected the lake has alternated between being full and dry. At the present time it is dry which is supposed to be the fourth time in eighty years.

The first record of the lake being dry was in 1878, only three years after this country was surveyed. In 1882 it was at a record high. A series of dry seasons brought a low level in 1894. The first artesian well was drilled in 1898, and another a year or two later. These were to provide a continual supply of water for Indian cattle. From 1898 to 1924 the lake was full, reaching a maximum depth of 18 feet. In 1921 considerable damage was done to farm land due to high water. The lake was very low in 1934 so a five foot concrete pipe one and a quarter miles long, with control structure, was installed at the southwest end of the lake.to provide an outlet. The lake remained very low or dry through 1938 and 1939 when the two dikes were built. It slowly filled during the 1940's and spilled out the overflow in 1951. Since then the water level has been receding to the point where the lake was practically dry this year (1958).

There have been a number of artesian wells (at least seven) drilled around the lake. The first two, at Rest Haven, flowed for fifty years before giving out. The most recent one, just completed in 1957, is the only one flowing now. This is the third one drilled on refuge property at Owens Bay.

Lake Andes, when it has water, is a very productive lake for both fish and waterfowl. In fact the lake has been so famous

for its bass fishing and duck hunting that when it does go dry there is considerable public demand to restore water at any cost. The lake is also an important wintering ground for waterfowl, with as many as 100,000 mallards wintering here at times. It attracts a very large flight of redheads, canvasbacks and scaup during the fall migration.

The function of Lake Andes in wildlife management, in order of importance, is to provide a refuge for redhead and canvasback ducks during the hunting season, a wintering area for mallards and Canada geese, a waterfowl production area, and public fishing. The major requirements for these functions are production of Sago pondweed, open water during the winter, a maximum amount of marshy edge with relatively low water, and a minimum of about four feet of water for fish. Apparently these objectives are not incompatible. Very likely the excellent fish production and the concentrations of divers are due to the very dense stands of sago pondweed and other aquatic plants.

There has been much public demand for a stable water level in the lake for recreational use. A study was made in 1952 of the possibility of pumping water from Ft. Randall reservoir. Other methods such as artesian wells and diverting water from other drainage areas have been explored. The latest proposal is connected with a Bureau of Reclamation irrigation project. An irrigation district is proposed for Brule and Charles Mix Counties and surplus irrigation water would be diverted to Lake Andes.

There is only one reported instance of botulism occurring at Lake Andes in late years. This was in 1949 when water levels were at an average height. There was imminent danger of a botulism outbreak this year when the lake went dry but nothing happened. Presumably conditions are not quite right for botulism. Lead poisoning is of greater importance. The lake has always provided good shooting and it probably has a high concentration of shot on the bottom. Lead poisoning appears every winter in the wintering flock of mallards.

B. Water Rights

Lake Andes is a meandered lake, meaning a permanent body of water with established shoreline and the State holding the water rights for the public. In 1939 the State of South Dakota gave the Bureau of Biological Survey a perpetual easement to the water rights of Lake Andes. Easements were also obtained from private property owners of the shoreline up to the high water mark, or meander line. In addition the Bureau of Biological Survey acquired complete ownership of 344 acres at Owens Bay (Secs. 5 & 6, T96N, R64W) plus ~~two~~ one small tract of upland on the North Unit. The Service also has title to the strip of land for the diversion ditch west of the lake in Sec. 5, T96N, R65W, and the concrete outlet tube in Sec. 9, T96N, R65W. There are no parties with prior rights to the water of Lake Andes.

C. Water Supply

Water supply is the big problem at Lake Andes. There is one artesian well at Owens Bay which is flowing at the rate of 1000 gpm or 1460 acre feet per year. This is the only dependable water supply.

1. Precipitation. According to the SCS Reconnaissance Report of 1958 (see Appendix), the total storage of the lake is 17,400 acre feet of water. The contributing water shed is estimated at 84,800 acres. The SCS has estimated the frequency of runoff from precipitation records as below:

Frequency of Occurrence		Runoff
80% chance	(1 in 1.25 yrs.)	- 1260 acre feet of water
50% "	(1 in 2 yrs.)	- 3300 " " " "
20% "	(1 in 5 yrs.)	- 96000 " " " "
10% "	(1 in 10 yrs.)	- 16,500 " " " "

It is obvious that a ten year frequency rain is needed to fill the lake, assuming it is dry. The SCS reports that "It is easily recognizable that there is insufficient precipitation and runoff to make all three units of the lake into areas capable of supporting fish on an average year." On the other hand the lake was reported dry in 1878, 1894, 1939, and 1958. This is approximately a 16 year, a 45 year, and a 19 year period between dry lakes, and from all reports there must have been fish in the lake most of the time when it had water.

There has been some feeling that construction of stock ponds and dams in the watershed will reduce the runoff into the lake, but the SCS points out that new drainage work in the watershed will probably counter-balance the effect of the stock ponds.

2. Artesian Wells. There have been at least seven artesian wells around the lake which have failed. Only one is functioning now, the well drilled in 1957 at Owens Bay. Due to corrosive elements in the well water, steel well casing does not last long and the well casing collapses. For durability a bronze or copper casing is required which is quite expensive.

The artesian head in the Lake Andes area has dropped 68 feet in the past 50 years according to the Geological Survey. There is still a head of 90 feet at this location but at the

present rate of decline artesian wells will cease to flow in about 70 years. Although the State Water Resource Board might approve replacement wells it is generally agreed that artesian water should be reserved for domestic use.

The latest well drilled cost $30,000 with non-corrosive casing and screen. This cost would be prohibitive for enough wells to maintain a stable level in the lake.

3. Additional Drainage. The diversion ditch west of Lake Andes which was to bring water from Garden Creek was plugged in 1955. This watershed covers 2560 acres and would normally contribute about 100 acre feet a year according to SCS figures. There is a possibility of replacing the plug with a culvert and rebuilding the embankment to prevent flood damage which occurred in 1955.

There is an area of 2000 acres in the hills south of Lake Andes which could be drained into the lake in the vicinity of the outlet. Because the area is steep and hilly runoff would be higher but would only contribute about 70 acre feet a year.

A third area of about 16,000 acres in the Corsica District northeast of Lake Andes might be drained into Andes Creek and the north unit. This would require possibly ten to fifteen miles of ditches plus destroying good pothole habitat for waterfowl.

4. Pumping Water from Randall Reservoir. This method would be the most dependable and most expensive method of putting water in Lake Andes. In 1952 the initial cost of pumps and canal was estimated at $430,000 with annual maintenance cost of $16,000. Benefits to wildlife and recreation do not justify this expense.

5. Irrigation Diversion. This is the latest proposal. The Bureau of Reclamation is working on the feasibility of the Brule - Charles Mix Irrigation project. A 1:1 cost to benefit ratio is necessary to justify the irrigation project. It appears the ratio is "slightly higher" in this case. The Bureau of Reclamation is getting irrigation districts organized and farmers signed up. It all depends on the attitude of the farmers. If the irrigation project is approved it is proposed to divert excess or waste irrigation water in Lake Andes for recreational use.

Of the five possibilities of water supply, precipitation is the only practical source at present. In a way this may be the best. It is a natural occurrence for the lake to alternate between low and high water levels and this may be connected with high fertility and aquatic production. Carp have been a problem in the past and they are naturally eliminated by a dry lake. It is desirable to manipulate water levels in lakes and marshes for better habitat control; in this case Nature is doing the job for us. With a constant supply of water there may very well be more of a problem in management than in its natural state.

D. Other Management Considerations

The primary reason for the value of the lake to wildlife, both waterfowl and fish, may be in its production of sago pondweed. The greatest danger to aquatic plant production is carp. They entered the lake in 1952 and there was a direct decline in aquatic plants, other fish, and diver use in relation to carp abundance. An eradication program was completed in 1958 at an approximate cost of $3200 which covered only a part of the lake.

Preventive efforts should include a fish screen at the outlet of the South unit, periodic checking of farm ponds in the watershed, and prohibition of minnows for bait in fishing.

There is a conflict in water for fishing and other recreational use, and waterfowl and aquatic plant production. Local people would like a maximum depth of water for fishing and boating while a minimum depth would be desirable for waterfowl. The past and present practice has been to store as much runoff water as possible in the North and South units, because they receive most of the runoff, and hold the Center unit relatively low. By holding as much water as possible in the North and South units it ensures carrying more water through drought periods, rather than spreading it over three units with increased evaporation loss.

At Owens Bay a better control of water is possible. The well supplies sufficient water to maintain any level, which can be adjusted by stop logs at the spillway. An experimetal program has been set up to determine the effect of flooding or exposing new areas of shoreline on waterfowl use and production. The purpose is to create relatively open stretches of shoreline for waterfowl loafing use, rather than maintaining a static water level with a heavy growth of emergent vegetation.

In 1957 Owens Bay was practically dry so that the pool bottom was well aerated and in good condition for pondweed growth. The plan is to maintain a 3.5 foot level in 1958 and raise the pool by half foot stages every year until the 6.5 foot level is reached. Then it will be drawn down by half foot stages until the 3.5 foot level is reached again. This should flood a new contour of low growing dry land plants every year on the way up, and expose a new contour of previously submerged bottom on the way down. At the same time the changing levels will not give emergent shoreline vegetation such as cattails as much chance to get established.

This will require a detailed record of changes in vegetation and ecological conditions as well as related waterfowl use and production. This has been done for 1958, at the 3.5 foot level.

Proposed Pool Levels for Owens Bay

1957 - Dry	1960 - 4.5'	1963 - 6.0'	1966 - 5.5'	1969 - 4.0'
1958 - 3.5'	1961 - 5.0'	1964 - 6.5'	1967 - 5.0'	1970 - 3.5'
1959 - 4.0'	1962 - 5.5'	1965 - 6.0'	1968 - 4.5'	1971 - Dry

If conditions warrant it the schedule may be interrupted as necessary. For example, if pondweed production should begin to decline it might be necessary to drain the bay about 1965. If the half foot intervals are not enough to flood new expanses of shoreline it may be necessary to raise the pool more. Any changes such as these would be incorporated in the Annual Water Management Program, as well as a report on conditions for the past year.

E. Recommendations

(1) Objectives

The objective in water management at Lake Andes, as much as it can be managed, is to hold as much water in the lake as possible to carry it through periods of drought. Because the North and South units receive the bulk of the runoff water these pools should be filled first before filling the Center unit which receives less runoff. Until a dependable water supply is assured for Lake Andes this policy of storing as much water as possible must have precedent over any other objectives, except in Owens Bay. In fact the natural pattern of water supply over a long period has probably been as effective as could be done with controlled management.

It is recommended that the twelve year program of water manipulation to control shoreline vegetation experimentally be followed to determine the use of newly flooded or exposed shoreline by waterfowl.

When there is sufficient water in the lake to support fish, every effort should be taken to prevent the introduction of carp. Periodic checks should be made of the farm ponds in the Lake Andes watershed to prevent flood water from carrying undesirable fish into the lake. This can probably be done in cooperation with the State Dept. of Game, Fish and Parks since they have an interest in providing public fishing.

It will also be necessary to do something about preventing carp from entering the lake from the outlet in the event the South unit fills enough to spill out through the outlet tube. There is a fish screen at that outlet but it is in poor condition and should be rebuilt. This will require plans and estimates by the Branch of Engineering.

It is also recommended that when and if there is sufficient runoff to fill the North or South units that these units be filled to the crest of 97.6 for the South unit and 99.1 for the North unit before filling the Center unit.

If public demand to get water in Lake Andes keeps up some method of pumping or diverting water into the lake will probably be devised at a future date. This will require some drastic revisions in the Water Management Plan, and also some revision in the physical structures to facilitate manipulation of water levels in the various units, and to dewater them when necessary.

Approved:

Submitted by:

David C. McGlauchlin

David C. McGlauchlin

12/18/58

BENCH MARKS & SPILLWAY ELEVATIONS FOR LAKE ANDES

Outlet Structure, South Unit	Crest.....	100.00*
	Flow line.....	96.15
Outlet tube (5 ft. diameter)	Flow line.....	94.63
Structure in South Dike	Crest.....	97.6**
	Flow line.....	90.6
Structure in North Dike	Crest.....	99.1
	Flow line.....	92.1
Owens Bay spillway	Crest.....	104.27
	Flow line.....	98.27

* Arbitrary elevation of 100.00 feet for Lake Andes corresponds to mean sea level elevation of 1437.25 feet. Geological Survey Bench Mark is along Railroad right-of-way, approximately 100 yards west of Outlet structure for South unit.

** Crest of structure in South Dike may be 98.8 with stoplog extension added in 1952.

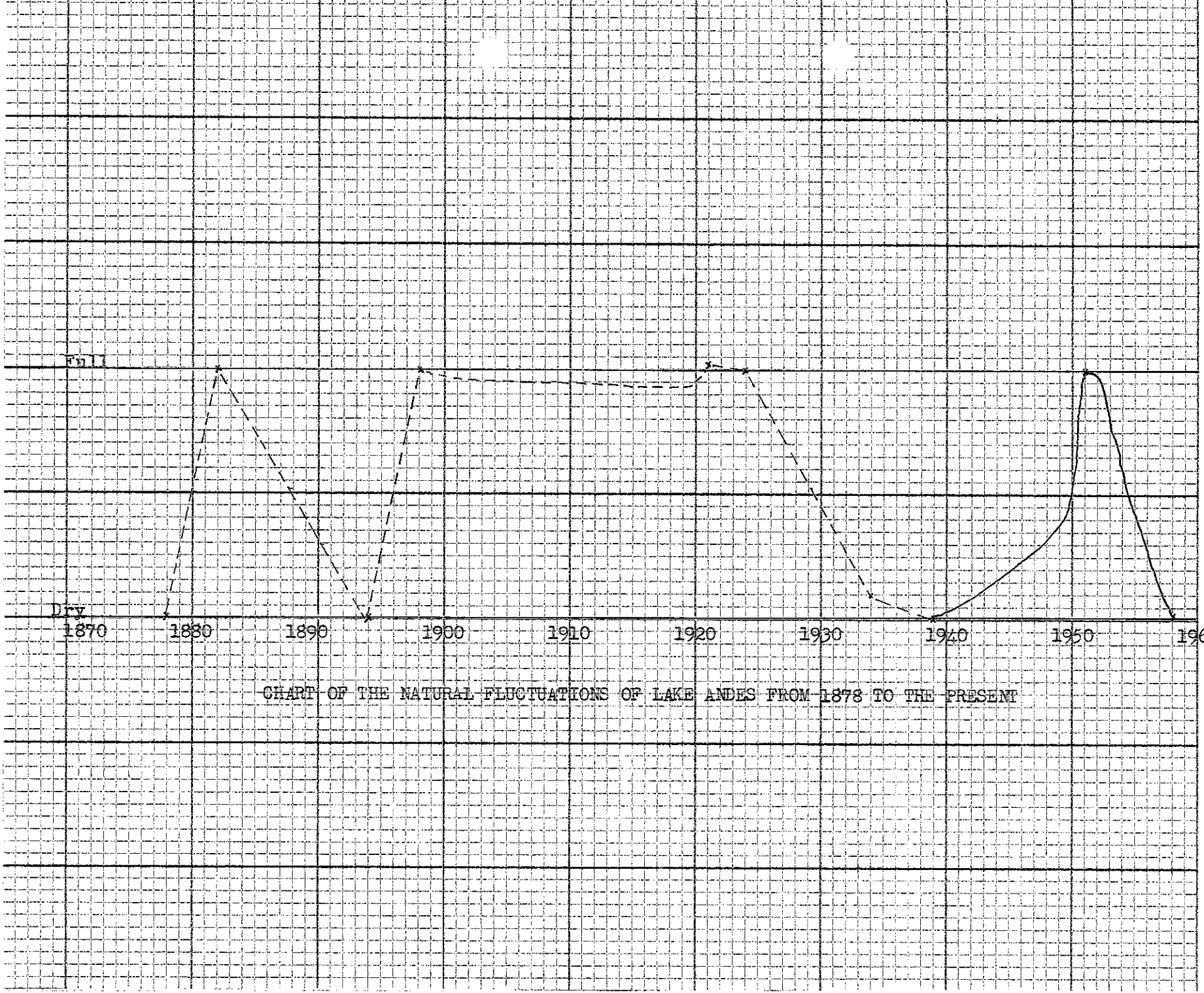

CHART OF THE NATURAL FLUCTUATIONS OF LAKE ANDES FROM 1878 TO THE PRESENT

COPY OF SCS RECONNAISSANCE REPORT, LAKE ANDES WATERSHED, 1958

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Huron, South Dakota

Reconnaisaance Report
Lake Andes Watershed
July 7 & 8, 1958

Personnel participating:

Clarence Brehm, Conservation Engineer, SCS, Huron, S.D.
James P. Hughes, Work Unit Conservationist, SCS, Lake Andes, S.D.
LeRoy Shearer, Biologist, SCS, Huron, S. D.
Gordon Stroup, Agricultural Engineer, SCS, Lake Andes, S.D.
Ray Huxhable, Party Leader, Watershed Work Plan Party, SCS, Huron
Les Nelsen, Game Warden, Dept. of Game, Fish & Parks

A. Purpose and Objective of Report

This report is to supply additional information to the Dept. of Game, Fish & Parks per their request dated May 27, 1958.

The objective of the report is to summarize data pertaining to precipitation and runoff from the various watershed areas. From this material some general observations and conclusions are presented.

B. References used during Reconnaissance

Available studies and surveys made in the past by various agencies and groups were reviewed. This data was supplemented by making a field tour and through interview with local technicians.

Reports reviewed were:
1. Study by Lake Committee of the Lake Andes Chamber of Commerce with recommendations. July 1955.

2. Water Conditions and Gauge Readings in Lake Andes - Dave McGlauchlin, U. S. Fish and Wildlife Service

C. Factors to be Considered

1. Precipitation and Evaporation

From information available in other reports, office data, etc. and without the benefit of field surveys, estimates were made of

Important

the drainage areas, water surface areas, depth, storage and evaporation volumes of each part of the lake area represented by the north, middle and south units. In considering the lake as a whole, there is not enough runoff from precipitation to supply the entire lake area.

It was estimated that Lake Andes has a contributing watershed of about 84,800 acres. Based on Soil Conservation Service procedures, we have estimated the following runoff by frequencies:

80% chance of occurrence (1 in 1.25 yrs) - runoff - 1260 acre feet
50% chance of occurrence (1 in 2 yrs) - runoff - 3300 a.f.
20% chance of occurrence (1in 5 yrs) - runoff - 9600 a.f.

When the entire lake is filled to the spillway (or outlet levels) it was estimated that the total storage is:

North unit - 1700 acresfeet
Middle unit - 8400 acre feet
South unit - 7600 acre feet

Total - 17,700 acre feet

A ten year chance of occurrence, or ten year frequency, would produce a runoff of about 16,500 acre feet. In other words, a ten year frequency storm is needed to fill the entire lake area assuming the lake was dry at the time the runoff occurred.

Evaporation reduces the water stored in the lake to a considerable extent and must be considered in estimating the volume of water that is available. Using the most recent figure of 14 inches of evaporation per year, over and above normal precipitation, storage losses were determined.

2. Runoff from Present Contributing Areas

If the entire 84,800 acres of drainage above Lake Andes is broken down into contributing areas, the areas above each unit are approximately as follows:

North unit - 53,000 acres
Middle unit - 11,600 acres
South unit - 20,000 acres

Since the average runoff is inadequate to make a good lake of all three units, consideration was given to determining the runoff to each area. The following table relates the runoff in inches, volume in acre feet and evaporation volume for the frequencies that are important to this study:

(See Table 1)

3. Sedimentation

Sedimentation has occurred in the lake area although it does not seem to be serious in reducing the water storage potential of the lake itself. The contributing areas have discharged silt in flat waterways where native vegetation and weeds have trapped most of the silt before it reaches the lake. No borings were made and it is not considered necessary to do so at this time.

4. Storage of Water in Dams or Dugouts Above the Lake

Additional dams and dugouts are continually being constructed in the upper reaches of the watershed. At the same time, new drainage work brings in additional water into the main waterways. It was assumed that for the present these practices are counter-balancing each other with regard to runoff water reaching Lake Andes.

D. Sources of Additional Water

1. Wells

Numerous wells for additional water supplies have been dug along the shoreline of the lake in the past. These wells have been short-lived, generally less than 10 years. Only one well is functioning at present. This well is discharging into Owens Bay at an estimated rate of 1000 gallons per minute.

Assuming that a well would flow 1000 G.P.M., the expected volume per day would amount to 4 acre feet per day or 1460 acre feet per year.

2. Diversions

The possibility of diverting water from other watersheds exists in two locations. In the past a diversion was built west of the city bringing additional water into the South unit of the lake. The watershed behind this diversion is approximately 2560 acres. After the diversion was constructed a high intensity rain in this area caused some flooding. Because of this the diversion was blocked and the runoff waters allowed to return to the original channel. With a minimum expenditure and some improvements this diversion could be restored.

TABLE 1

Unit	Drainage area in acres	Total Storage in Acre Feet	Inches of Runoff by % Chance or Occurrence			Runoff in Acre Feet by % Chance or Occurrence			Evaporation in Acre Feet by % Chance or Occurrence			Net Volume of Water in Acre Feet by % Chance or Occurrence		
			80	50	20	80	50	20	80	50	20	80	50	20
North	53,000	1400	0.18"	0.47"	1.37"	796	2490	6050	430	580	580	366	1910	5470
Middle	11,600	8400	0.18"	0.47"	1.37"	174	455	1328	48	125	360	126	330	968
South	20,200	7600	0.18"	0.47"	1.37"	303	791	2308	84	220	640	219	571	1668
Totals	84,800	17,400				1273	3736	9686	562	925	1580	711	2811	8106

Another area constituting about 2000 acres could be diverted into the South unit from south of the lake. The diversion could follow the old railroad grade built during the construction stages of Fort Randall dam.

These two areas are steeply rolling to hilly. Better than 50 percent of the area is poor rangeland. The runoff from this area would be relatively high, both from snow melt and rainfall.

A summary of the potential from these two areas is as follows:

Diversion west of lake (2560 acres)

80% chance	100 acre feet
50% chance	220 acre feet
20% chance	515 acre feet

Diversion south of lake (2000 acres)

80% chance 75	75 acre feet
50% chance	167 acre feet
20% chance	400 acre feet

3. Drainage

A third area consisting of approximately 16,000 acres could be diverted into Lake Andes. This area lies in the north-eastern part of Douglas County. At the present time a large ditch drains a portion of the area into Platte and Choteau Creeks. The ditch, as it exists, does not give adequate drainage for the area.

The terrain is characterized by shallow depressions and sloughs and under normal conditions contribute little in the way of runoff.

Although inclement weather and poor roads prevented the party from viewing the area, a study of aerial photographs showed a possibility of diverting this 16,000 acre area into Lake Andes Creek and subsequently into the north unit of Lake Andes.

It is felt that this area, because of its larger size, would be of considerable benefit in bringing additional water into the lake and at the same time provide an adequate outlet for the proper management of periodic yields of excess water on the cropland.

4. Diversion from Fort Randall Rservoir

A study has been made by the U.S. Fish and Wildlife Service, the South Dakota Dept. of Game, Fish and Parks, the Corps of Engineers and local people on the possibility of pumping water from Fort Randall Reservoir into Lake Andes. The total estimated cost is $430,000 with an annual operating and maintenance cost of $16,000. The average annual beneifits to wildlife is estimated at $17,000. The final analysis by the Corps of Engineers was that the project was not economically feasible because of the high costs. The wildlife interests feel the project was feasible and the project should have been included as part of the Fort Randall project.

5. Diversion of Water as Part of Irrigation Projects or Collection of Irrigation Waste Waters

The Bureau of Reclamation is currently preparing a report on the feasibility of irrigating lands in the Lake Andes area. Some of the canals may come close to the lake. It would, therefore, be possible to divert waters from these canals into the lake, especially during periods when irrigation waters are not being used. Waste waters from the irrigated lands plus drainage of irrigable lands could contribute materially to the lake water supply.

At a minimum of cost Lake Andes could be materially benefited as an indirect benefit of irrigation in the area.

E. Conclusions or Recommendations

It is easily recognizable that there is insufficient precipitation and runoff to make all three units of the lake into areas capable of supporting fish on an average year. Neither is there enough water on a frequency of one in two years, or on a five year frequency. A ten-year storm or a buildup of rather wet years are the only situations where the lake will be full. It appears that an effort should be made to make good fishing areas of the north and south units leaving the middle unit dry, or only as a catch basin for the overflow from the two units.

Drilling and development of water producing artesian wells is costly but could serve as a supplemental measure. If wells are constructed, brass casing is necessary to prolong the life of the wells. It can also be expected that artesian flows will be reduced in future years as has been the case with many other similar wells throughout the state. It would be best to conserve the artesian basin for domestic uses.

Diverting water into the South Unit appears feasible. The

engineering would not be particularly difficult and cost should not be excessive. The yield in the South Unit for an 80% chance would be increased from 219 acre feet to 394 acre feet or 44%. For a 50% chance, the yield would increase from 571 acre feet to 958 acre feet or 40 percent. The yield from a 20 percent chance of once in five years would increase from 1668 acre feet to 2583 acre feet or 35 percent. Water yield from the area west of the South Unit will roughly correspond to the amount lost on an average by evaporation. Once the lake is at a maximum elevation, it could be expected that the extra water from the diversions would materially help maintain the lake surface at a constant level over extended periods. During drought periods or low runoff years, these areas would not sustain a constant lake level.

Draining extra water into the North Unit or diverting waters from other watersheds possibly has limited potential. A quick survey of the area in northwestern Douglas County might be profitable.

Direct pumping of water from the Fort Randall Reservoir could be the most positive solution. Because of the high installation costs, plus high operation and maintenance costs, it appears that this method cannot be considered at this time.

Extra water as a result of irrigation in the Lake Andes Watershed appears to be the most promising solution at some future date. Extra water drained from depressions in the irrigated area, plus waste waters and seepage waters could be a very dependable and economical source. This water would be obtained without any direct cost to the lake. There would be a possibility to pump water during the colder months with the pumps and canals used for irrigation. The operation and maintenance costs for this operation would be similar to that for a single purpose system.

From available weather data, it appears that under existing conditions, the lake can enjoy high water levels only 5 - 10 years out of each 20 years. For the immediate future it is our opinion that the North and Middle Unit will have to be operated as they are at present. Some definite improvement can be accomplished by diverting two additional areas into the South Unit.

The long range future for the lake seems to depend on irrigation waters that may be brought into the area. If these things can become reality, Lake Andes may again become known as "The World's Best Bass Lake."